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A PROTOTYPE HYDROHANDLING SYSTEM for SORTING and SIZING APPLES BEFORE STORAGE

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Prepared by
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and

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PREFACE

The basic principles for the apple hydrohandling system described herein were developed during a cooperative investigation by Michigan State University and the U.S. Department of Agriculture.

The prototype equipment was developed by Michigan State University under a research contract with the U.S. Department of Agriculture. The equipment was designed in cooperation with Fred Durand, Jr., President of the Durand-Wayland Machinery Co., and constructed by his firm at Woodbury, Ga. The site and facilities for testing this system were furnished by Belding Fruit Sales, Inc. and Belding Fruit Storage, Inc., Belding, Mich., through the courtesy of W. H. Braman, President.

Grateful appreciation is expressed to the above-named firms and individuals, and also to the many others whose assistance and contributions were essential and vital to the success of this project.

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A PROTOTYPE HYDROHANDLING SYSTEM FOR SORTING AND SIZING APPLES BEFORE STORAGE

by

B. A. Stout, D. H. Dewey, E. G. Vis,
and Joseph F. Herrick, Jr. 1/

INTRODUCTION

Apples for conventional and controlled atmosphere cold storage in many fruit growing areas are stored directly from the orchard without sorting and sizing. This practice has been widely accepted because (1) it facilitates the movement of the apples into storage immediately upon harvest, (2) usually there is a shortage of competent help and management for a sorting operation during the harvest season, and (3) apples, especially the soft-fleshed varieties such as McIntosh, are quite susceptible to bruising and other mechanical injuries during sorting and sizing on presently used equipment.

Modern trends in the handling and storage of apples, however, have increased the potential benefits of presizing and presorting storage fruit. Potential advantages of presizing are (1) expensive cold storage space could be utilized more efficiently, (2) the fruit could be inventoried and segregated by size, quality, and condition so as to facilitate final packing and marketing, and (3) lots of fruit could be evaluated as to grade and size and recorded at the beginning of the storage season so as to provide valuable information to the grower and perhaps permit pooling of lots in storage. The use of pallet boxes (bulk handling) has increased the need for presizing and presorting because apples of different qualities are combined and cannot be recognized or separated readily upon receipt at the storage. 2/ At the same time, bulk handling has made presizing and presorting more difficult because of the damage likely to occur to the fruit upon dumping and refilling the pallet boxes.

1/ Drs. Stout and Dewey are professors of Agricultural Engineering and Horticulture, respectively, and Mr. Vis is Graduate Assistant in Agricultural Engineering, Michigan State University; Mr. Herrick is Investigations Leader, Horticultural Crops, Handling and Facilities Research Branch, Transportation and Facilities Research Division, United States Department of Agriculture, Agricultural Research Service at Hyattsville, Md.

2/ Although this report uses the term pallet boxes, these are variously referred to in different areas as bulk boxes, pallet bins, bins, pallet containers, and bulk containers. The pallet box used for apples holds 16 to 25 bushels and has approximate outside dimensions of 48 by 40 inches with an inside depth of 30 inches.

The success of water submergence devices used for dumping apples from pallet boxes suggested water as a likely medium of handling. Studies were conducted, therefore, to investigate the properties and characteristics of apple fruits related to sizing, sorting, and filling into boxes with water as the handling medium; and to design, construct, and evaluate various components for a sizing, sorting, and box-filling system. 3/ Results of these studies and of tests with small-scale pilot model components for sizing and filling boxes justified the construction and test operation of a complete prototype system. The design of the apple hydrohandling system described here is based on the findings of that study. Earlier studies of a hydrohandling system for apples were made by Matthews. 4/

DESIGN OF THE HYDROHANDLING SYSTEM

The purpose of the hydrohandling system is to receive apples from pallet boxes of 16- to 20-bushel capacity, eliminate undersize fruit, pass the apples over a sorting area where culls are removed, separate apples by size, and return them to pallet boxes at a rate up to 600 bushels per hour. Unique methods of sizing the fruit and for filling bins in water, which had been conceived and tested in the laboratory, were developed and incorporated into the experimental system. The major components of this prototype, as shown in figure 1, are a flotation dumper, a hydroeliminator, a roller sorting table, a hydrosizer, and two hydrofillers. The experimental system is located outdoors adjacent to an apple storage and packing warehouse (fig. 2).

Flotation Dumper

The flotation dumper (figs. 3A and B) consists of a tank of water and a mechanism to submerge pallet boxes in the water and lift them from it. The flotation dumper submerges pallet boxes completely to permit the apples to float away from the boxes at the water surface. The unit constructed for this system is similar to a commercial model, but modified to increase its capacity and to include a hydroeliminator in the tank. An impeller pump with a capacity of about 1,000 gallons per minute recirculates the water from a storage tank at the end of the dumper tank to the submerging end of the dump tank. The water capacity of the dumper tank is approximately 2,800 gallons.

The pallet box submerging mechanism is mechanically operated by an electric motor moving a pinion gear on a gear rack. A hydraulically activated arm connected to the submerging mechanism holds the box in position. When completely submerged, the top of the box is approximately 6 inches below the water surface.

3/ Dewey, D. H., Stout, B. A., Matthews, R. H., Bakker-Arkema, F. W., and Herrick, Jr., J. F. Development of a hydrohandling system for sorting and sizing apples for storage in pallet boxes. U.S. Dept. Agr. Mktg. Res. Rpt. No. 743. 31 pp. illus. 1966.

4/ Matthews, R. H. A hydrohandling system for presorting and presizing apple fruits. Thesis for the degree of M.S., Mich. State Univ., East Lansing. 1963. (Unpublished.)

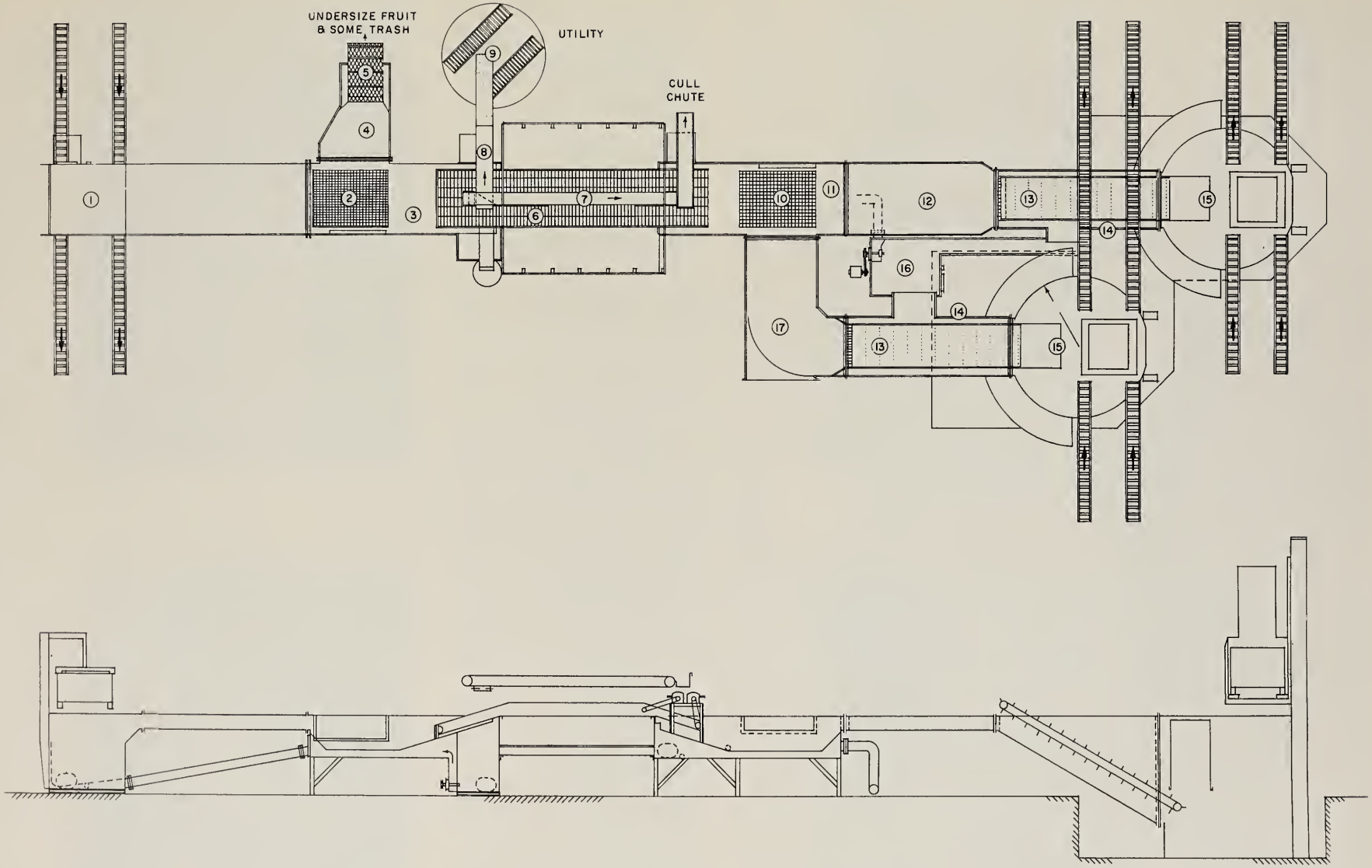

Figure 1.--Line diagram of prototype hydrohandling system showing (1) flotation dumper, (2) hydro-eliminator, (3) continuation of dumper tank, (4) lateral flume, (5) flight conveyor, (6) roller sorting table, (7) utility and cull conveyor, (8) utility conveyor, (9) dry pallet box filler, (10) hydrosizer, (11) hydrosizer tank, (12) main flume, (13) submerging conveyors, (14) tanks for submerging conveyors, (15) hydrofillers, (16) storage tank for water, and (17) lateral flume.

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Figure 2.--The prototype hydrohandling system. The platforms along the sides were built for observation of tests.

The floating apples are moved away from the box and toward the hydroeliminator by a forced water current. A surge area 15 feet long is provided between the submerging mechanism and the hydroeliminator. The tank is 5 feet wide. A bushel of apples in a single layer occupies approximately 5 square feet, so there is space for 15 bushels of apples to accumulate between the submerging mechanism and the hydroeliminator to supply the system during the time required to remove the empty box and submerge the next full box. For a rate of 600 bushels per hour, 20-bushel-capacity pallet boxes are emptied at 2-minute intervals.

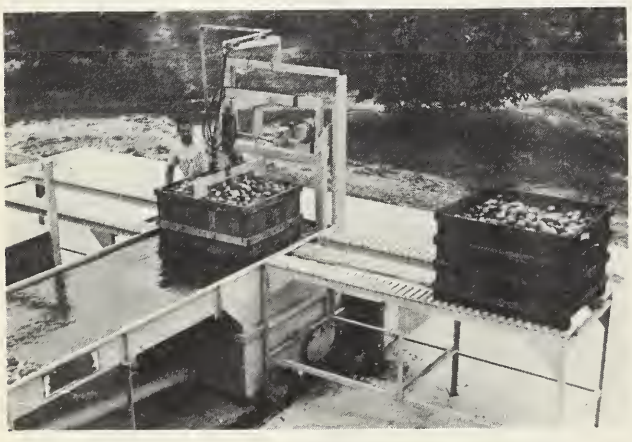

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Figure 3.--(A) A pallet box of orchard-run apples being submerged by the flotation dumper; and (B) apples floating away from the box at the water surface.

Hydroeliminator

The purpose of the hydroeliminator (fig. 4A and B) is to separate the smallest apples (less than 2 1/4 inches in diameter) from the system before the fruit reaches the sorting area. A moving sizing chain with hexagonal openings submerges all the fruit, and buoyant force moves the small apples up through the chain openings to the water surface. A water current moves the small fruits perpendicular to the main flume into a lateral flume where they are elevated out of water by a flight conveyor and dropped into a pallet box.

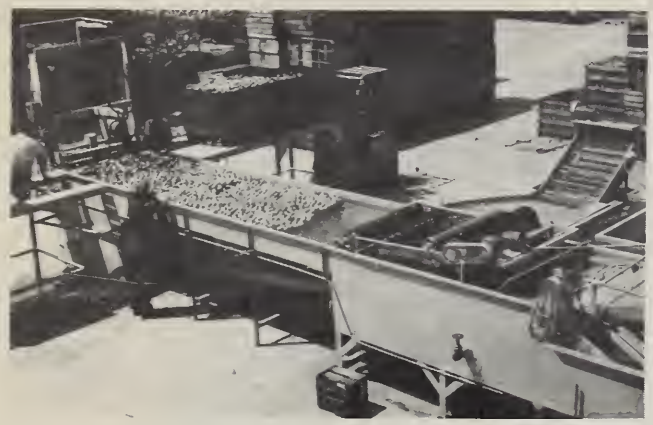

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Figure 4.--(A) The hydroeliminator at the end of the flotation dumper tank. Apples smaller than 2 1/4 inches in diameter pass upward through the chain openings of the hydroeliminator and are carried by water current into a lateral flume (at right in picture). (B) The larger apples are carried under the sizing chain into the main flume and are elevated from the water by the roller conveyor of the sorting table.

A sizing chain 4 feet wide operated at a speed of 40 feet per minute provides the required capacity of 600 bushels per hour. The angle of submergence and positioning of the hydroeliminator in relation to the lateral flume are adjustable. Baffles are utilized to guide the apples to the chain and to prevent their contact with the framework and sprockets. The chain is rubber-coated as an aid to minimizing mechanical damage to the apples.

Apples larger than 2 1/4 inches in diameter are carried beneath the chain and return to the water surface beyond the hydroeliminator unit. Directed currents of water at this point assure positive movement of fruit toward the end of the tank. The water flows over a weir at the end of the dumper tank to maintain a constant water level, necessary for uniform sizing at the hydroeliminator. The water at the weir falls through a power-operated wire belt which removes leaves, sticks, and other debris from the water.

Roller Sorting Table

A modified version of a conventional roller sorting table is used for hand removal of defective fruit (fig. 5). The roller conveyor of the sorting table elevates the apples from the water of the dumper tank at an angle of 17 degrees. An overhead water spray removes dirt, leaves, and debris from the apples as they are elevated to the sorting table. The sorting space, which is a continuation of the roller conveyor in a level plane, is 10 feet long, 4 feet wide, and divided into 6 lanes.

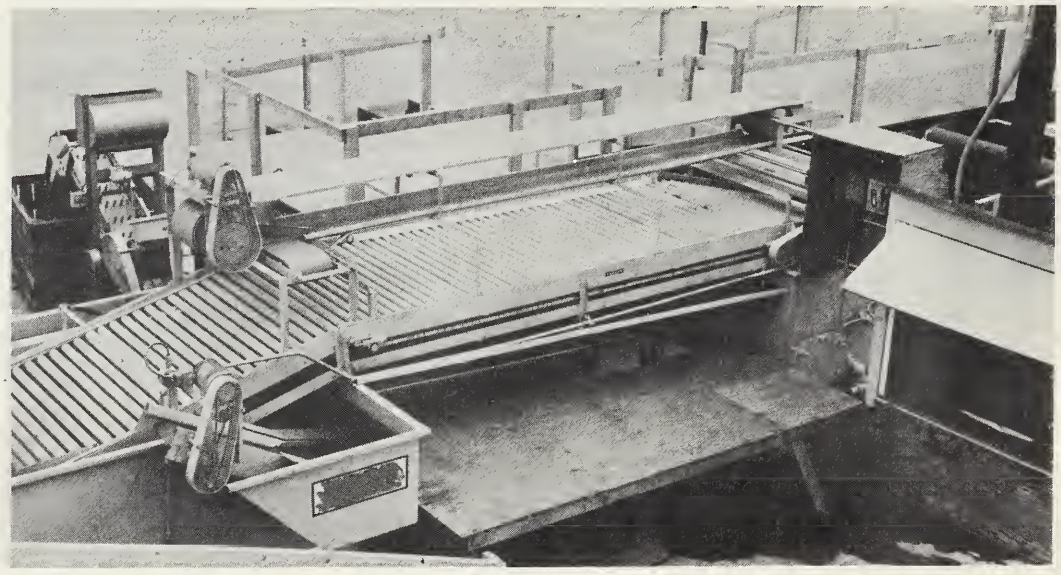

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Figure 5.--The roller sorting table (lanes will be installed later). Utility apples are placed on lower belt above the table and are carried off by a cross-conveyor to a conventional dry pallet box filler (at left rear). Cull apples are placed on the upper belt and are diverted to a gravity chute (not visible in picture) at the end of the sorting table.

The rollers are rubber covered, 2 1/4 inches in diameter, spaced on 3-inch centers, and have a reverse roll to turn the apples with a forward rotation as they are translated over the table. Separate motors with variable speed drives are used for translation and rotation so that the rates of movement are easily adjusted. Translation rates of 20 to 40 feet per minute are provided. Rotation rates based on 3-inch diameter apples are adjustable from 1 to 2 revolutions of the fruit per foot of translation. Smaller fruit would rotate more times per foot of translation.

Workers sorting apples stand on wooden platforms constructed at the sides and 36 inches below the top of the sorting table conveyor. The defective fruits are placed on a utility and cull conveyor which is a closed loop belt above the roller sorting table. The lower belt, used for utility apples, is 14 inches above the table surface and the upper belt, used for culls, is 24 inches above the table. Utility apples are transferred from the belt to a cross-conveyor leading to a conventional dry pallet box filler which will

handle fruit at a rate up to 2.8 bushels per minute. The filler conveyor automatically raises with the level of apples and the pallet box rotates to assure uniform filling. The cull apples are diverted from the cull belt to a gravity flow chute leading into a pallet box.

A shelter could be added to protect workers at the sorting area. Fluorescent fixtures placed beneath the utility cull conveyor provide light when needed for sorting.

Hydrosizer

The sorted apples are returned to water by the rollers of the sorting table inclined at an angle of 17 degrees and are carried by water current to the hydrosizer for separation into two sizes (fig. 6A and B). Two flumes lead from the hydrosizer to the hydrofillers. The hydrosizer is identical to the hydroeliminator except for chain size. The apples are submerged by the chain, and those smaller than 3 inches in diameter pass upward through the chain openings and are carried in a water current to a lateral flume. Those 3 inches and larger in diameter remain under the chain, return to the water surface and float into the main flume.

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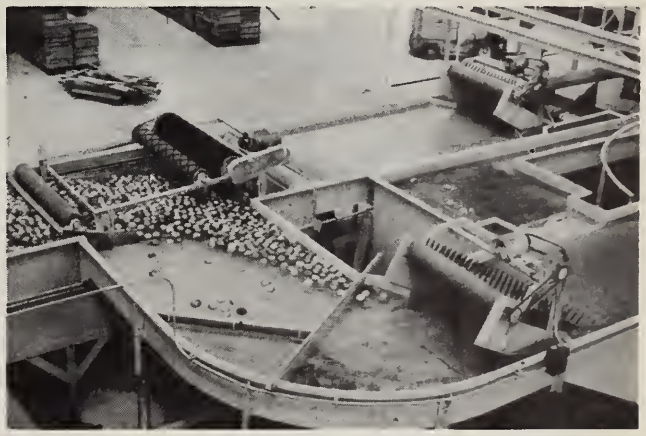

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Figure 6.--(A) The hydrosizer. Apples are returned to water from the sorting table for separation into two sizes by the hydrosizer. (B) The large apples remain beneath the chain and return to the water surface in the main flume; the smaller apples pass up through the chain openings and are floated into the lateral flume. The submerging conveyors of the hydrofillers are at right in each flume.

Hydrofillers

Identical hydrofillers, one for each of the two sizes of sorted fruit, are used to return the apples to pallet boxes. Each unit consists of a circular water tank, a submerging conveyor, two accumulators, a rotating rack, and a mechanical lift (fig. 7). The tank is 10 feet in diameter, 8 feet 10 inches deep, and rests in a pit that is 3 feet 10 inches in depth. The submerging conveyors carry apples under water to the accumulators. Each accumulator is

36 inches wide, 44 inches long, and 50 inches high, and has a volume capacity equivalent to 25 bushels of apples to allow a 20 percent loose fill in water. The accumulators are open at both bottom and top. The cross-sectional area of the accumulator is slightly less than that of the smallest pallet box to be used; its height is adequate to provide for the capacity of the largest box.5/

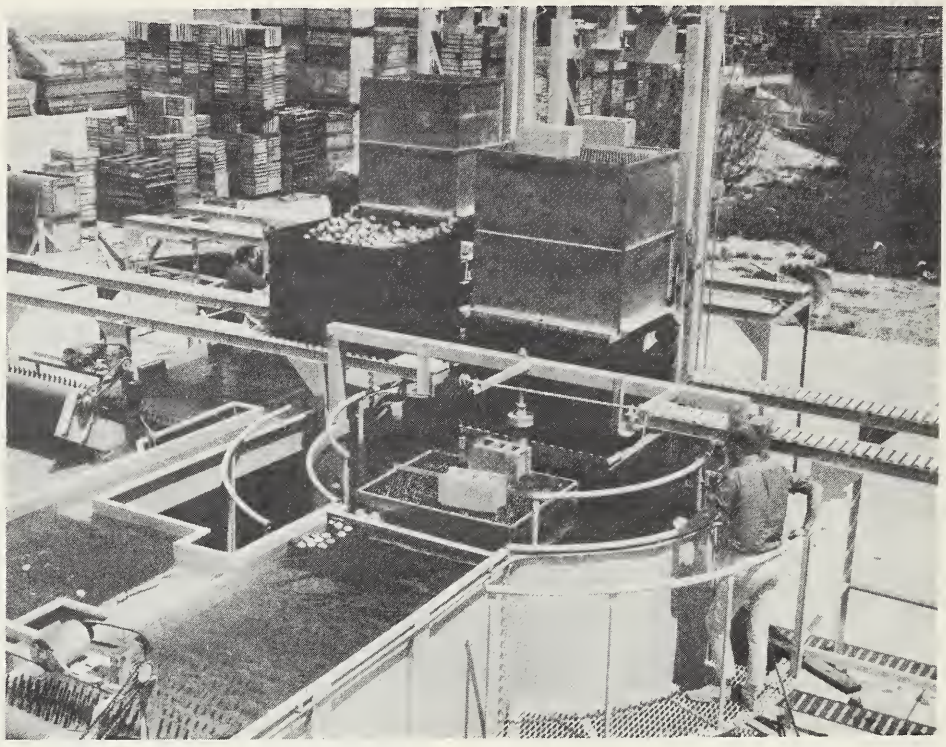

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Figure 7.--The accumulator of the hydrofiller in the foreground is being filled with apples by the submerging conveyor. The second accumulator has been lifted from the water tank together with a pallet box. The fruit is transferred to the box as it is raised above the water surface. (Grills and blocks were placed on the accumulators for testing.) A previously filled pallet box is shown to the left on a set of roller conveyors.

When both accumulators are in place in the tank, they rest on a rack mounted on a vertical pole in the center of the hydrofiller tank so they can be rotated simultaneously in a horizontal plane. A lift mechanism, similar in design and construction to that of the flotation dumper, is mounted on the opposite side of the tank from the submerging conveyor. It lowers one accumulator at a time and also lowers and raises a pallet box together with an accumulator. Guides on the lift mechanism serve to hold the box from floating upward while submerged, close the space between the box and accumulator during raising to prevent spillage of fruit during transfer to the box, and elevate

5/ Outside pallet box dimensions: 33 inches deep (including pallet), 40 inches minimum width (42 inches maximum) and 48 inches long.

the accumulator above the box when in the fully raised position. When out of water, the boxes rest on roller tracks that are aligned with tracks at each side of the tank to permit loading and unloading.

A filling cycle is initiated by placing an accumulator in the tank in position to receive fruit from the submerging conveyor. The submerging conveyor carries apples from the flume downward at a 30 degree angle from the horizontal to a level 1 1/2 feet below the lower edges of the accumulator. The conveyor belt is 3 feet wide and has flights 2 inches high at 6-inch intervals; when operated at a speed of 60 feet per minute, its capacity is approximately 12 1/2 bushels per minute. The apples are buoyed upward into the accumulator upon leaving the submerging conveyor.

While the first accumulator is being filled, an empty pallet box is placed on the mechanical lift and positioned beneath the other accumulator, which has been raised to the maximum height of the lift. These two are lowered by the lift into the tank of water.

When the first accumulator has been filled, the submerging conveyor is stopped, and the operator manually rotates both accumulators 180 degrees around the center pole. Once the empty accumulator is in the filling position, the submerging conveyor is restarted. The first accumulator is now directly above the submerged pallet box and ready for emptying. The apples are transferred from the accumulator to the pallet box as accumulator and box are lifted simultaneously from the water. The filled box is rolled from the lift by hand and replaced with an empty box to start a new cycle.

The design capacity of each hydrofiller is 600 bushels per hour, even though in practice this probably will never occur because utility and cull apples and other sizes of apples are removed or directed elsewhere. To meet this capacity, a 20-bushel pallet box would need to be filled every 2 minutes. Since only 15 seconds is needed to rotate the accumulators, 1 3/4 minutes is available to fill the accumulator.

Other features of the hydrofiller include a catwalk around the filling unit for the operator, a handle for rotating the accumulators, and a weir in the tank to control the water level. The water flowing over the weir passes to a storage tank for recirculation by means of a large impeller pump. There is a drain plug and a clean-out door at the bottom of each filler tank and at the entrance to the flume. The approximate water capacity of each hydrofiller tank and connecting flume is 8,700 gallons.

Power Requirements

All motors larger than 1/3 horsepower on the system are connected to 3-phase, 220-volt electrical outlets, and the lights and the small motors are connected to single-phase, 110-volt electrical outlets. The full load ampere rating for the system is about 65 amps.

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TESTS OF ACCUMULATORS

Several methods of determining the quantity of apples in the accumulator are being tested. Since the specific gravity of apples is about 0.8 and nearly constant for a given variety of apples, approximately 1/5 of the apples in the unit extend above the water surface and may be readily measured. The inside surfaces of two accumulators are coated with Teflon[6/] to minimize friction between the walls and the apples as an aid to achieving a uniform rise of apples above the water surface. The quantity of apples in the accumulator is also being measured from the buoyant force of the apples. For this, the tops of two accumulators are closed and the accumulators are submerged for filling. A spring scale mechanism connected to the top measures the buoyant force which can be calibrated to indicate the quantity of apples in the accumulator.

6/ Trade names are used in this publication solely for the purpose of providing specific information. Mention of commercially manufactured products does not imply endorsement by the Department of Agriculture over similar products not mentioned.